

Implementing a Smart Landing Facility for Mixed Traffic

Tim Pratt, Eric Shea, Charles Florin
Virginia Tech, ECE Department

NASA CNS Conference
May 21, 2003

SATS Program

- Small aircraft transportation system (SATS) for general aviation (GA)
- Some objectives:
 - GA aircraft that are safer and easier to fly
 - Greater utilization of GA aircraft and smaller airports
 - Near all-weather operation

SATS Smart Landing Facility

- Smart Landing Facility (SLF) concept :
- Greater utilization of non-towered airports
- 2000 airports in the US have a paved runway, no tower, no landing navigation aids
- Smart Landing Facility concept makes better use of these airports
- Objective: Double number of movements/hr

SATS Aircraft

- SATS aircraft have high tech avionics
- Head-up displays, autopilot, augmented GPS ... autoland?
- Artificial VMC operation in Instrument Meteorological Conditions (IMC)
- Full SATS implementation will take a long time
- 200,000 GA aircraft in US; most have mode-C transponders

SATS Smart Landing Facility Problem

- SATS aircraft can land in IMC without assistance from navaids other than GPS
- Majority of aircraft landing at any GA airport will have mode-C transponders in foreseeable future
- Mode-C equipped aircraft must follow published approach and departure procedures in IMC

Typical GA Airport: KBCB

- Capacity of GA airport without a tower is three to six movements per hour in IMC
- Example: KBCB
- Virginia Tech / Montgomery County Airport
- Elevation 2140 ft. No radar below 3,200 ft.
- Paved Runway, 4550 ft. No tower
- Approaches: Localizer, NDB, GPS-RNAV
- Approach Control: Roanoke (ROA ATC)



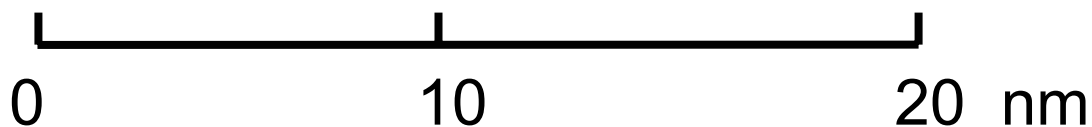
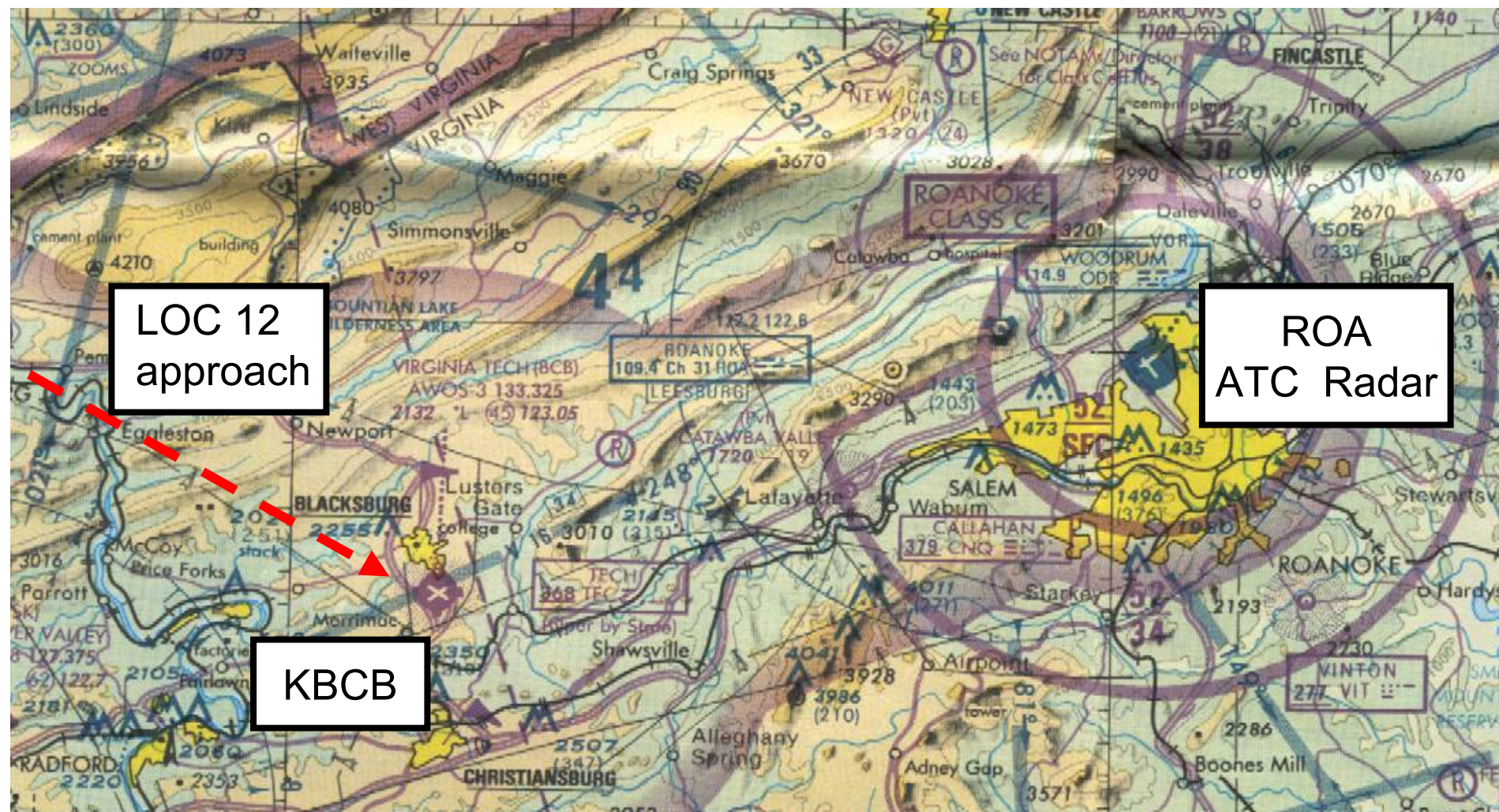
↑ N



↑ E

May 21, 2003

NASA CNS Conference
Copyright Tim Pratt May 2003

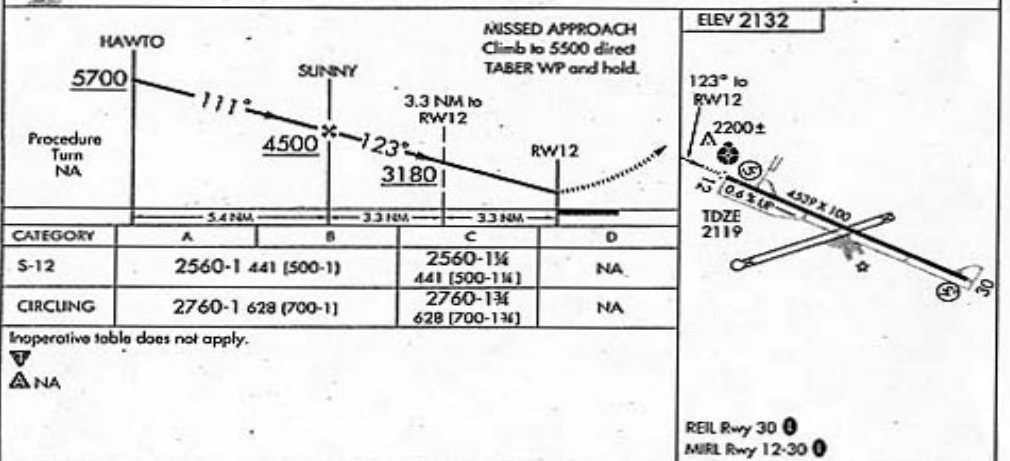
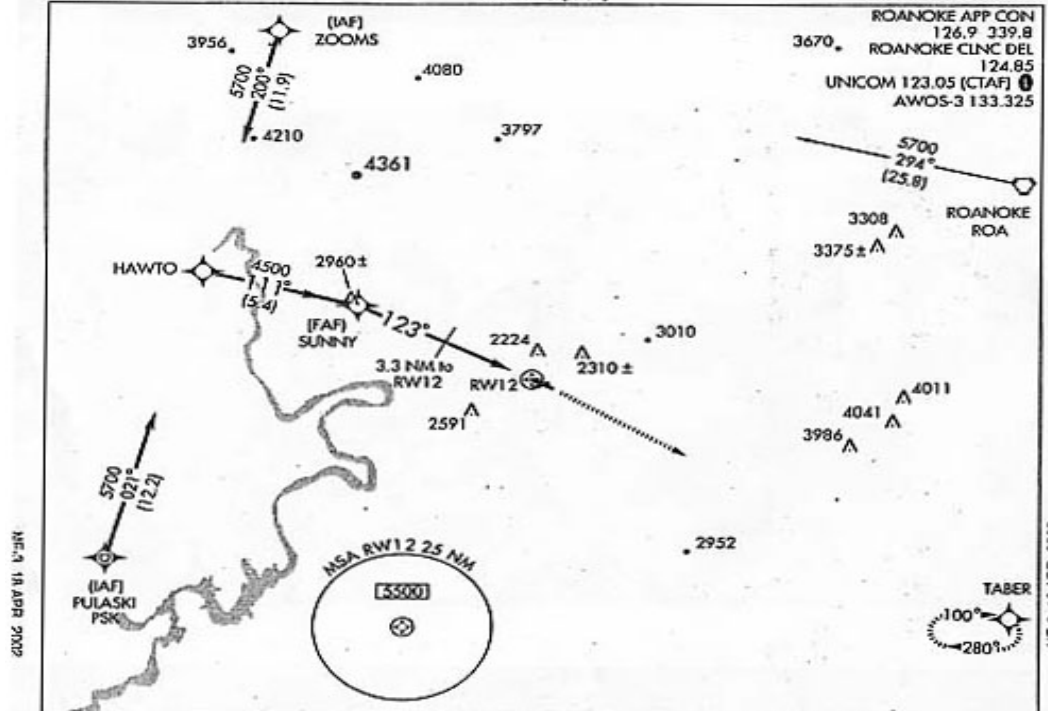


May 21, 2003

NASA CNS Conference
Copyright Tim Pratt May 2003

KBCB LOC-12 Approach

- Localizer approach to Runway 12 at KBCB:
- Radar vectors from ROA ATC to initial fix
- Fly approach
- Land or execute missed approach
- Call ROA ATC on 126.0 or by telephone
- Next aircraft can now fly approach, or depart
- Elapsed time: approx 15 minutes
- GPS, NDB approaches take similar time



KBCB SATS Concept

- SATS concept of any approach to KBCB
- Radar vectors from ROA ATC to initial fix
- Fly approach as if in VMC
- Any SATS aircraft can see any other SATS aircraft
- Next SATS aircraft can fly approach or depart at will
- Elapsed time: same as for visual conditions

The Smart Landing Facility Problem

- Concept works well if all aircraft are equipped to SATS standard
- Mode-C aircraft must fly published approach
- One aircraft with mode-C transponder blocks all SATS traffic for 15 minutes
- Airport movements still only 3 or 4 per hour
- Mixed traffic capability is needed

The Smart Landing Facility

- Implementing the Smart Landing Facility for mode-C transponder equipped aircraft
- Requirements:
 - ATC must know location of every aircraft
 - Pilots should know location of all aircraft
 - Operation must mirror visual flight rules

Locating Aircraft in IMC

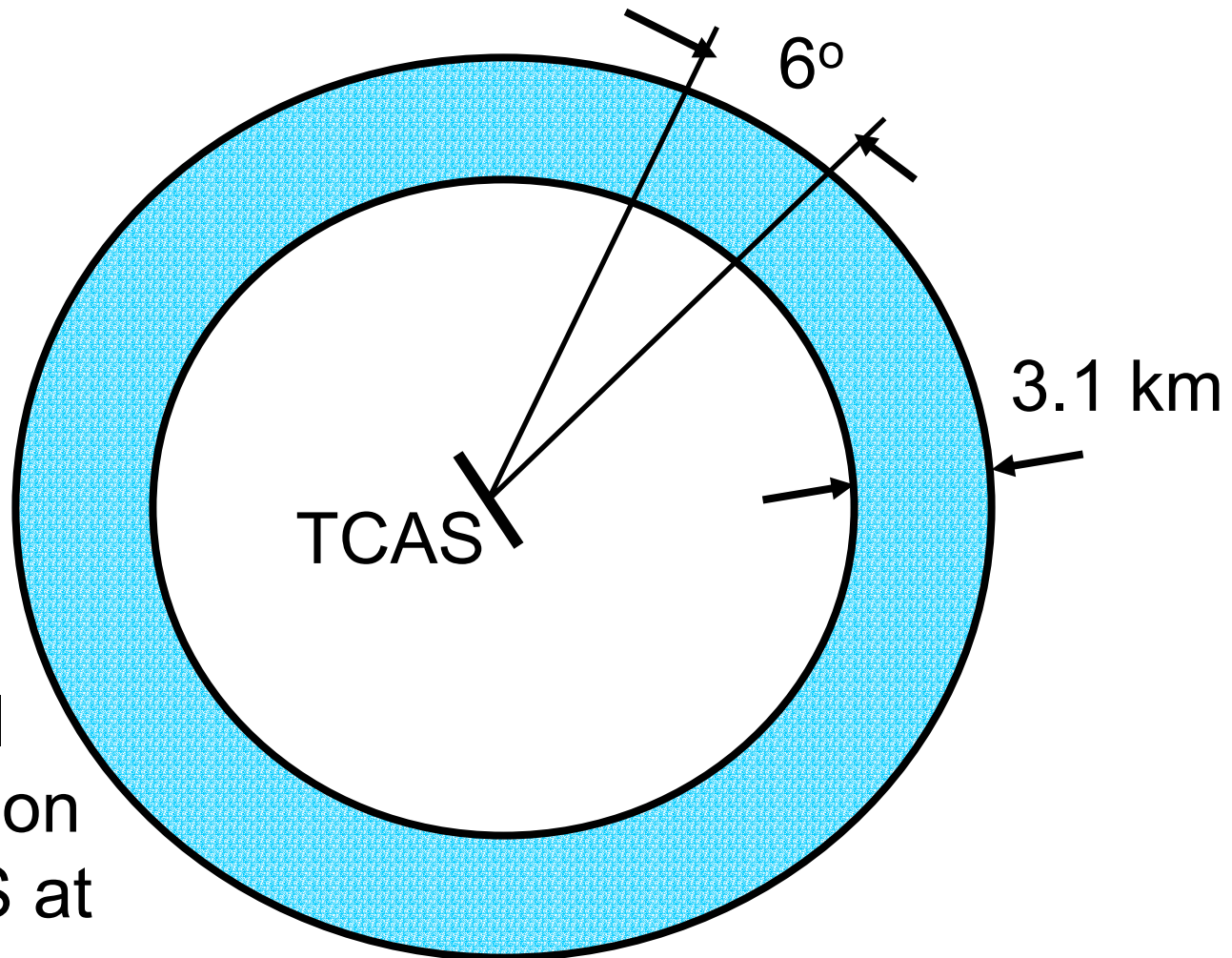
- Available systems are:
 - Secondary radar
 - Multilateration
 - Mode-S transponder (GPS transmission)
 - Traffic Collision Avoidance System (TCAS)
 - Position Reporting Beacon (GPS transmission)

Locating Aircraft in IMC

- Solutions for small GA airport:
- Mode-S transponder (GPS transmission)
- TCAS on a stick
- Position Reporting Beacon (GPS transmission)
- TCAS on a stick is only current solution with mode-C transponder equipped GA aircraft

TCAS on a stick

- TCAS – III unit finds range and bearing to any mode-C equipped aircraft
- Same operating mode as secondary radar
- Mode-C transmission lasts 20.8 μ s
- Occupies 3.1 km in space
- Aircraft at similar bearing within 3.1 km in range have overlapping responses
- TCAS uses “whisper-shout” technique

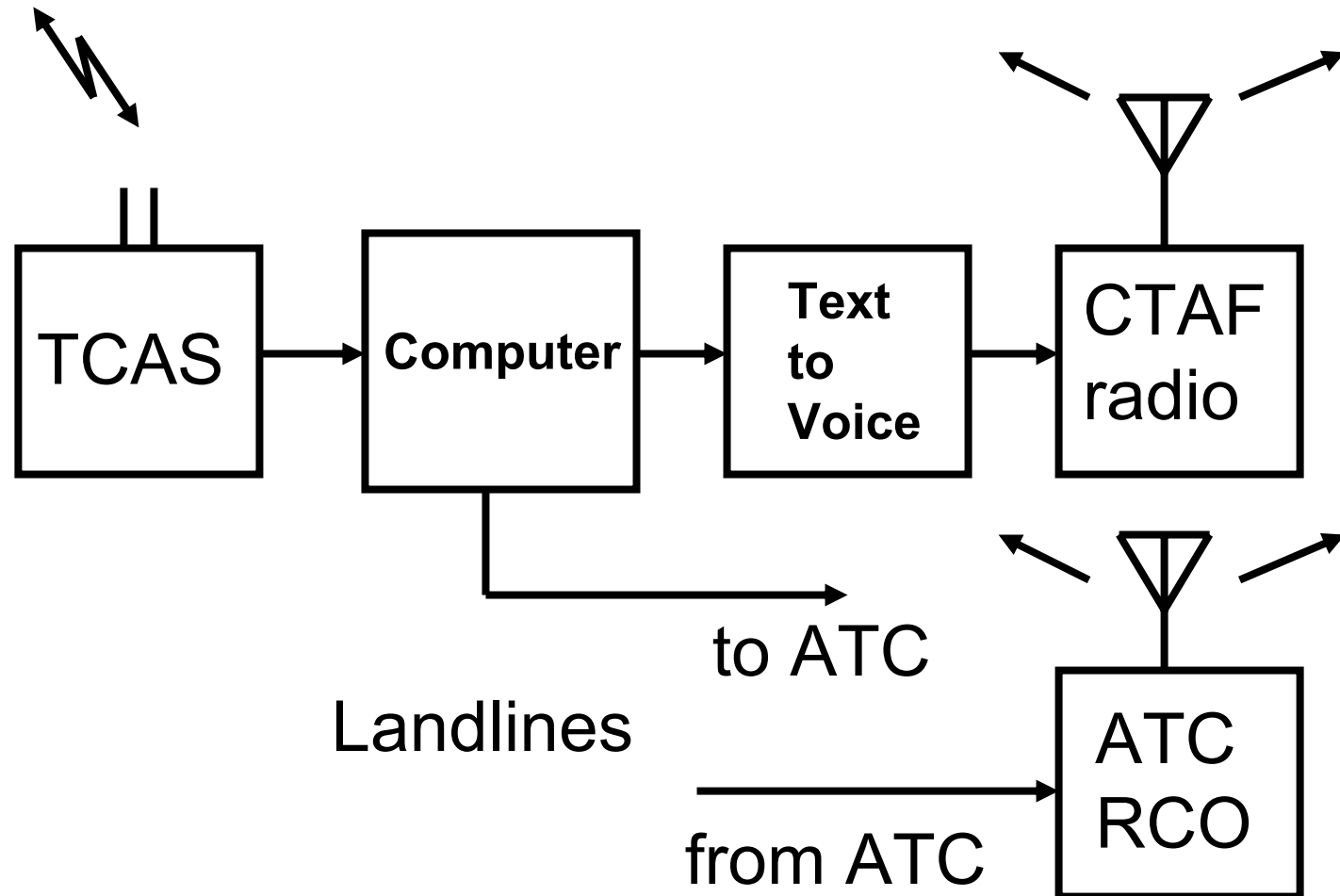


Nominal
Resolution
of TCAS at
longer ranges

Separating aircraft in space

- Link TCAS unit to computer and CTAF radio
- Text to voice converter provides traffic advisories to pilots
- Specific advisories by squawk code
- Landline provides TCAS data to ATC
- Aircraft can be displayed on ATC radar screen

Automated traffic advisory system at SLF

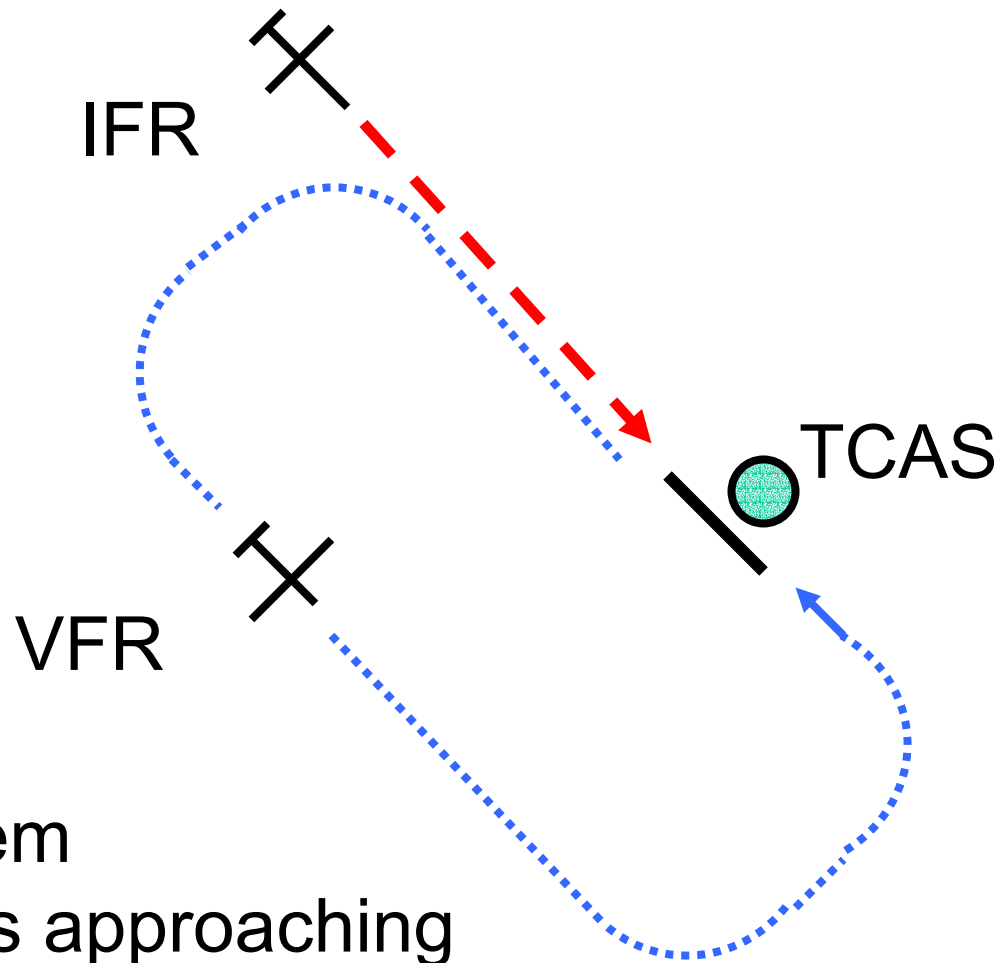


Separating aircraft in space

- All aircraft enter and leave SLF airspace under local ATC control
- TCAS-computer sends aircraft range, bearing and altitude data to ATC
- Flight paths must be arranged to avoid conflicts
- New rules required

SLF Concept in VMC

- The SLF concept works in Visual Meteorological Conditions
- Provides traffic advisories to pilots approaching airport
- Especially valuable in MVFR and haze
- All aircraft must have mode-C or mode –S transponders



System
warns approaching
IFR traffic of VFR traffic in pattern

Improving the SLF Concept

- Range resolution of secondary radar and TCAS is a limitation
- Greater than 3.1 km separation is required with mode-C transponders
- Mode-S transponder offers GPS C/A code resolution - better than 0.1 km
- Adoption rate of mode-S transponder by GA aircraft owners likely to be low

Improving the SLF Concept

- One solution is a GPS position indicating beacon on all aircraft
- Transmit position and aircraft ID every two seconds
- Replaces TCAS as position location device
- All aircraft must have beacons for system to work well
- Subject of another presentation

The Smart Landing Facility

- Extension of original SATS concept
- Upgrade capacity of non-towered airports in IMC to 6 to 8 per hour
- Improve safety in MVFR and haze
- No additional equipment required on aircraft
- Installation cost significantly lower than secondary radar
- Can be implemented now

Acknowledgement

- This work was supported in part by the NASA SATS program through the Virginia SATSLab
- Eric Shea is a former graduate student at Virginia Tech, now serving with the US Navy in submarines
- Charles Florin is a former graduate student at Virginia Tech, and a graduate of Superlec in Paris, France.